Appendix F

Ian Drew/USFWS

Floodplain forest habitat along the Magalloway River

Ecological Land Units and Their Relationship to Refuge Habitat Type

Ecological Land Units and Their Relationship to Refuge Habitat Types

Introduction

During conservation planning processes, habitat, and therefore vegetation, becomes a key element in evaluating a planning unit's contribution to conservation targets. Not only is it necessary to know the current habitat within the planning unit, it may also be necessary to know the potential habitat that could occur in the future. Past and current logging practices have influenced the species composition and do not necessarily represent the vegetation that would naturally occur at a given site. During the Comprehensive Conservation Planning process at Umbagog National Wildlife Refuge, it became necessary to determine potential forest habitats based on site capabilities due to past and current harvesting and the lack of data on lands outside the current refuge boundary.

Detailed soil inventories, often used to determine site capabilities, were not available for the entire planning unit, which is located in northern New Hampshire (Coos County) and western Maine (Oxford County). Kuckler's Potential Natural Vegetation, Refuge specific Order II level soil survey data, photo interpretation, and consultation with forest ecologists were combined with ecological land units (ELUs) to predict sites with favorable conditions for naturally growing hardwood, softwood and mixed wood.

Data Layers

A spatial analysis was conducted using the geographic information system (GIS) ArcMap9 to predict naturally occurring forest habitats based on available abiotic and vegetation data. A base layer of ecological land units (ELUs), which are a composite of broad abiotic data displayed in 30 meter pixels developed by The Nature Conservancy (Mark Anderson, TNC Eastern Resource Office, Boston, MA), was overlaid with more site specific data to assign conifer, mixed and hardwood habitat types to ELU types. Each data layer is described below followed by the method that was used to make the assignments.

Kuchler's Potential Natural Vegetation.
In 1964, A. W. Kuchler of the University of Kansas mapped the conterminous United States depicting the vegetation that would exist if man were to allow plant succession to proceed without interference. The map incorporates abiotic geographical elements similar to Bailey's ecoregions (Bailey 1997) and results in vegetation types. The map is generalized and broad with its mapping units, however, it is of finer delineation than Bailey's ecoregions (Kuchler 1964).

Umbagog NWR planning unit lies within the Northern Hardwoods-Spruce Forest. A tall, dense forest of broadleaf deciduous and needleleaf evergreen trees. This is a mixture of; sugar maple (*Acer saccharum*), yellow birch (*Betula allegheniensis*), beech (*Fagus grandifolia*), and conifer; red spruce (*Picea rubens*) and hemlock (*Tsuga Canadensis*), with components of balsam fi r (*Abies balsamea*), red maple (*Acer rubrum*), paper birch (*Betula papyrifera*), red and white pine (*Pinus resinosa, P. strobes*).

Photo-Interpretation
To obtain a sense of the forest conditions prior to the most recent logging activity, photo interpretation of the Mollidgewock drainage was conducted by biologist, Bill Zinni (U.S. Fish and Wildlife Service, Hadley, MA), using 1986 color infrared aerial photographs. According to New Hampshire wildlife biologist, Will Staats, this would have been about the time the timber industry began to intensively select softwoods to meet the demand for pulpwood. Through photo interpretation, areas were classified as spruce/fir, northern hardwoods, mixed wood and recently harvested. Ground truthing was conducted to verify photo signatures.

The photo interpretation resulted in the mapping of contiguous linear segments of spruce/fir in the lowland areas and blocks of hardwoods and mixed wood in the uplands along with small blocks of conifers at the higher elevations. Areas of active harvesting in the uplands were apparent in the photographs. Many of the areas classified as hardwoods had skid trails throughout the parcel, indicating recent logging activity. In some areas, skid trails were coming from patches of conifers which appeared to be in a stage of harvesting, indicating the selective logging of conifers within mixed wood stands. Based on the apparent alteration logging had on the upland habitat, the most confident interpretation occurred in the mapping of lowland spruce/fir areas where logging had not taken place at the time of the photographs.

Refuge-specific Order II Soil Survey Data.
In 2004, the USDA Natural Resources Conservation Service (Homer 2004) conducted an Order II soil survey for portions of the refuge that are capable of forest management based on the refuge forest operability map. The descriptions for the soil map units were used to assist with determining the suitability and potential of a soil unit for specific uses, such as timber growth. The forestry component, of the soil unit description, identifies the type of tree growth and successional trends to be expected for each soil unit. Soil units that overlapped with low lying ELUs (where photo interpretation was most confident) were grouped into softwood, hardwood or mixed soil types based on the tree growth potential and successional trend (table F.1.)

Table F.1. The name of soil units that overlapped with low lying ELUs, and the assigned soil type based on forestry properties and most productive tree species.

#	Soil Unit Name	Forestry Properties	Tree species to manage	Soil Type
567	Howland silt loam	Softwood or hardwood, depends on surrounding seed source.	Eastern arborvitae, E. white pine, white spruce	Softwood
670	Tunbridge-Berkshire-Lyman Complex	Too diverse to generalize successional trends.	Balsam fir, E. white pine, larch, red spruce, white spruce	Softwood
247	Lyme fine sandy loam	Fair to good softwood growth, successional trends towards balsam fir and red spruce.	Eastern white pine, white spruce	Softwood
73	Berkshire very fine sandy loam	Hardwoods in combination with red spruce and balsam fir.	Balsam fir, E. white pine, red pine, white spruce	Softwood
61	Tunbridge-Lyman-Rock Outcrop Complex	Too diverse to generalize successional trends.	Balsam fir, E. white pine, red spruce, Scotch pine, tamarack, white spruce.	Softwood
27	Groveton fine sandy loam	Hardwoods in combinations with red spruce, balsam fir and occasionally white pine and hemlock.	E. white pine, paper birch	Mixed
579	Dixmont very fine sandy loam	Hardwoods in combination with red spruce and balsam fir.	Eastern arborvitae, E. white pine, European larch, white spruce	Softwood
523	Stetson fine sandy loam	Successional trends toward red spruce and balsam fir.	Eastern white pine, red pine	Softwood
590	Cabot gravelly silt loam	Poor for hardwood growth and good for softwoods, especially red spruce and balsam fir.	Eastern white pine, white spruce	Softwood
79	Peru fine sandy loam	Hardwoods in combinations with red spruce, balsam fir and occasionally white pine and hemlock.	Eastern white pine, white spruce	Softwood
995	Wonsqueak mucky peat	Tamarack, cedar, black spruce and alders with balsam fir.	- - -	Softwood

Forest Ecologists Site Visit.

U.S. Forest ecologists Bill Leak and Steve Fay, and USDA-Natural Resource Conservation Service soil scientist Joe Homer, accompanied the core team to sites with various forest conditions on the refuge. At each site, current conditions, soil type and projected successional paths were discussed in relationship to forest management techniques. It was noted that at many of the sites a higher component of hardwood species was present than the soils and site conditions represented.

Based on the soils, topography and species present at a site, the forest ecologists determined if the site conditions would naturally support conifer, hardwood or mixed woods. The sites that were classified as mixed wood, had a lesser degree of conifers than the ecologists thought would be present given the site capabilities. This corresponds to the interpretation of the 1986 aerial photographs.

Ecological Land Units (ELUs).
Ecological land units were developed by classifying and categorizing three abiotic data layers: elevation, bedrock geology and topographic features (Groves 2000). Lake Umbagog lies within the Northern Appalachian/Boreal Forest Ecoregion, as defined by The Nature Conservancy. Using GIS, Mark Anderson of the TNC New England Resource Office, Boston, MA, created ELUs for this Ecoregion by combining the 26 abiotic features listed in table F.2.

Table F.2. Abiotic data layers that were used to develop Ecological Land Units in the Northern Appalachian/ Boreal Forest Ecoregion

Elevation Zone	Bedrock Geology	Topographic Feature
0 – 800 ʻ	Acidic Sediment / Meta-sediment	Steep Slope
800 – 1700′	Acidic Granitic	Cliff
1700 – 2500′	Coarse Sediment	Flat Summit / Ridgetop
2500 – 4000′	Fine Sediment	Slope Crest
	Calcareous Sediment / Meta-sediment	Low Hilltop (flat)
	Moderate Calcareous Sed. / Meta-sed.	Low Hill (gentle slope)
	Mafic / Intermediate Grantic	Sideslope NW-facing
	Ultramafic	Sideslope SE-facing
		Dry Flats
		Wet Flats
		Valley / Toe Slope
		Bottom of Steep Slope
		Cove / Draw NW-facing
		Cove / Draw SE-facing

Some of the combined elements did not occur within the Northern Appalachian/ Boreal Forest Ecoregion and were dropped. Others were found to have no significant difference and were combined, resulting in the following ecological land units in table F.3.

Table F.3. Ecological Land Units of the Northern Appalachian/Boreal Forest Ecoregion

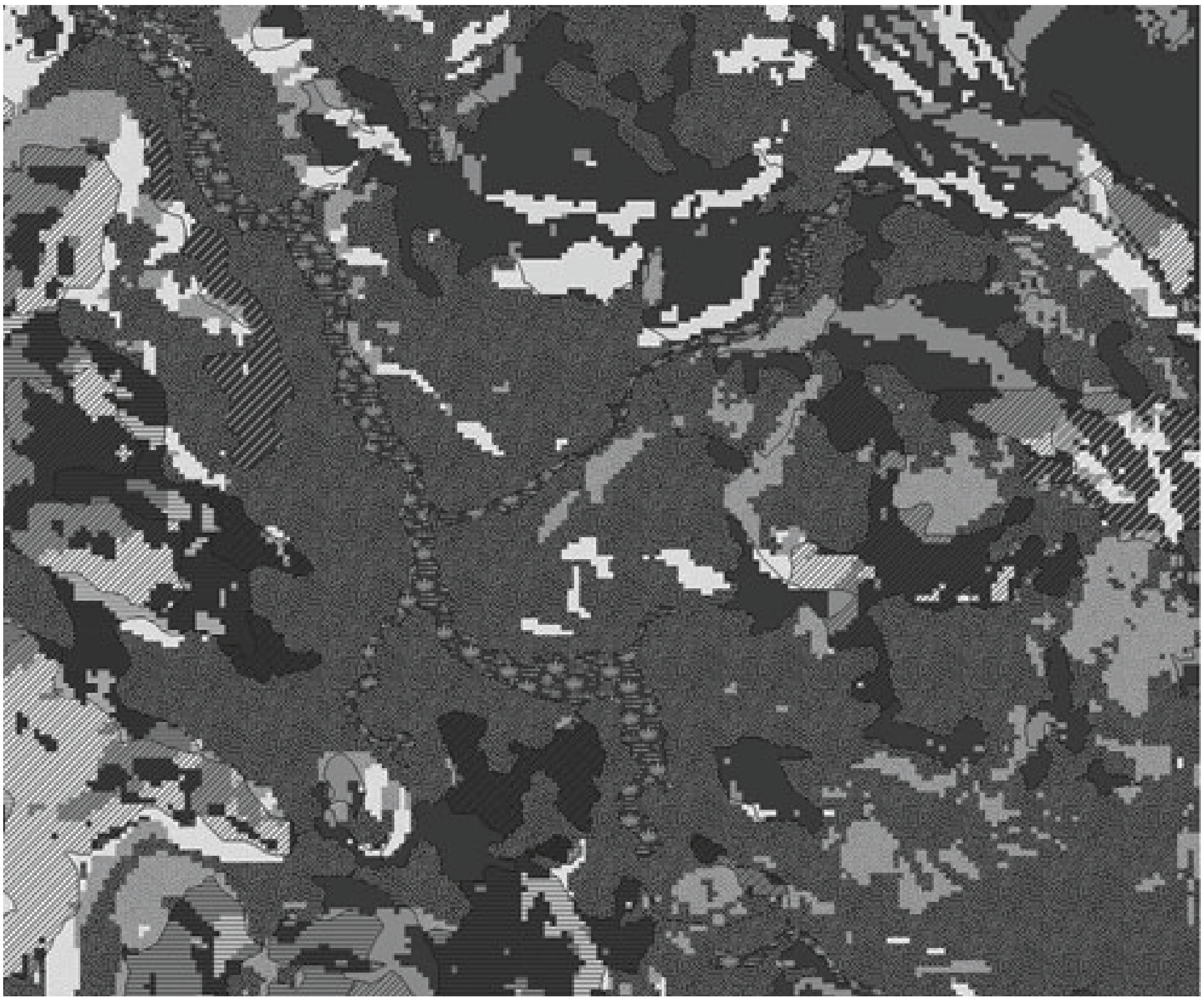
Ecological Land Unit
GSF_low hill/valley, acidic granitic
GSF_low hill/valley, acidic sed/metased
GSF_low hill/valley, mafic/int granitic
GSF_low hill/valley, mod calc sed/metased
Bottom of steep slope
Cliff
Coarse seds on dry flats, GSF
Cove NW facing
Cove SE facing
Dry flats, acidic granitic
Dry flats, mafic/intermed granitic
Flat summit/ridgetop
Sideslope NW facing
Sideslope SE facing
Slope crest
Steep slope
Wet flats
Wet flats on coarse seds
Dry flats, mod calc sed/metased

Methods

Using ELUs as a base in GIS, the photo interpretation layer was overlaid as a see-through texture to identify areas of positive correlation for spruce/fir, mixed and hardwood areas. There was a strong visual correlation between the low lying and mountain top ELUs and the areas mapped as spruce/fir. The location of each stopping point of the forest ecologists site visit were identified on the ELU layer as well. At each point the projected habitat type was correlated to the underlying ELU.

As depicted in figure F.1, the low lying ELUs correlated to areas that were interpreted as spruce/fir stand types (black areas with white specking) and the uplands to hardwood (gray areas with black diagonal strips) and mixed stands (gray with black horizontal strips).

Figure F.1. Ecological land units are shown in black and shades of gray. The black represents the softwood ELUs. The white speckling represents spruce/fir areas interpreted from 1986 aerial photography. Black hatching represents mixed and hardwood areas.



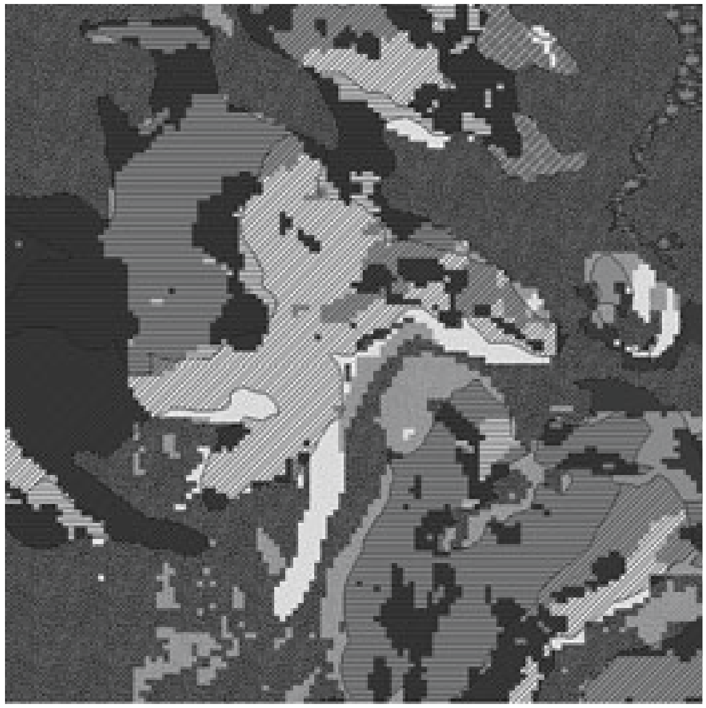


Figure F.2. Ecological land units shown in black and shades of gray, with an overlay of forest habitat shown as white speckling (softwood), black diagonal (hardwood) and black horizontal (mixed)

Figure F.2. shows an example where specific ELUs correlate with areas that were interpreted as hardwood and mixed wood based on the 1986 photos. ELUs are the base layer shown in black and shades of gray. The white speckling and black hatching lines are overlaid and represent forest types interpreted from 1986 aerial photography. The light gray ELUs correspond with areas that were interpreted as hardwood stands, the mid-shade of gray ELUs correspond to areas that were interpreted as mixed wood stands.

The Order II soils data was overlaid as a see-through texture just like the photo interpretation layer. The minimum mapping unit for the soil units of 3 to 5 acres resulted in polygons that overlapped more than one ELU, which are aggregates of much smaller units (30 meter square pixels). Soil polygons that contained more than 50% of a single ELU were chosen for the correlation to that soil unit. The correlation of softwood soil units to low lying ELUs was strong. A few of the combination soil units were too diverse to enable a prediction of the successional trend or were dependant upon the available seed source from adjacent areas. In these instances the adjacent soil type was generally a softwood type, leading to the conclusion of that soil unit to be a softwood type.

Discussion and Results

During the late 1800's and early 1900's, northern New Hampshire and western Maine were heavily logged. The current forest is the result of second or third re-growth. Some areas have recently been logged and are at a very early stage of re-growth. Past and current harvesting have influenced the species composition and do not necessarily represent the vegetation that would naturally occur at a given site. Knowing the tree species that would best grow on a site is necessary to direct the growth of regenerating sites as well as to manage for the species that flourish with site capabilities in more established sites, maximizing management efforts and supporting healthy forest conditions.

In April, 2001, FWS established a Biological Integrity, Diversity, and Environmental Health policy 601FW3 (Integrity Policy) to guide refuge management. The Integrity Policy states that refuge managers will use sound professional judgment during the comprehensive conservation planning process to determine the conditions which constitute biological integrity, diversity and environmental health. Sound professional judgment incorporates field experience, knowledge of refuge resources and the best available science including consultation with others both inside and outside the Service.

The Integrity Policy describes environmental health to be a composition, structure and functioning of soil, water, air and other abiotic features comparable with historic conditions. During the Umbagog CCP planning process we used available abiotic data in the form of ELUs to assist with determining site capabilities (softwood, hardwood, and mixed) which in turn reflect environmental health and management efficiency. In some areas the current vegetation correlated with ELUs that represented their current forest condition i.e. a hardwood ELU corresponded to site currently dominated by hardwood tree species.

Based on the methods described above, each ELU was assigned to represent either softwood, hardwood or mixed stand site capabilities. The ELUs were used to estimate the amount of softwood, hardwood and mixed wood habitat that would result for Umbagog NWR's CCP alternatives A, B and C. A projection of site capabilities was needed to assist with determining the most appropriate upland resources of concern (appendix H), developing projected forest conditions for current refuge lands, as well as for proposed additional lands outside the refuge boundary (appendix A – Land Protection Plan) in which the refuge lacks specific data on current conditions. Table F.4 lists the ELUs with the corresponding type of habitat that is projected to be represented for alternative A, B and C.

The ELUs for alternative A and C are the same because a continuation of current management (alternative A) and the decision to let nature take its course (alternative C) would result in the forest reflecting the site capabilities of each stand. In alternative A, it would take longer for the climax conditions to be fully represented given areas that may not reflect site capabilities because of selective logging. In alternative C, the refuge would be actively managing to attain natural climax conditions, and therefore reach those conditions sooner. The projected site capabilities for ELUs were used to determine acreages and can be used to guide future forest management strategies.

For alternative B, in which management is focused on priority resources of concern, the site capabilities of an ELU may be pushed toward forest conditions that are most beneficial to the selected species of concern, not necessarily to climax conditions. In alternative B, bird species dependent upon the mixed forest with a high conifer component were determined to be the priority upland resources of concern (appendix H). In this case, management to increase the conifer component of the mixed forest would be obtained by encouraging the establishment and growth of spruce and fir in ELUs that support softwood as well as any ELU that leans toward the growth of softwood.

Table F.4. ELUs and associated habitats for each of the alternatives for the Umbagog CCP.

Alternative A	Alternative B	Alternative C	Ecological Land Unit
Mixed	Softwood	Mixed	GSF_low hill/valley, acidic granitic
Mixed	Softwood	Mixed	GSF_low hill/valley, acidic sed/metased
Mixed	Softwood	Mixed	GSF_low hill/valley, mafic/int granitic
Mixed	Softwood	Mixed	GSF_low hill/valley, mod calc sed/metased
Mixed	Softwood	Mixed	Bottom of steep slope
-	-	-	Cliff
Softwood	Softwood	Softwood	Coarse seds on dry flats, GSF
Mixed	Softwood	Mixed	Cove NW facing
Mixed	Mixed	Mixed	Cove SE facing
Mixed	Mixed	Mixed	Dry flats, acidic granitic
Softwood	Softwood	Softwood	Dry flats, acidic sed/metased
Mixed	Mixed	Mixed	Dry flats, mafic/intermed granitic
Softwood	Softwood	Softwood	Flat summit / ridgetop
Hardwood	Mixed	Hardwood	Sideslope NW facing
Hardwood	Hardwood	Hardwood	Sideslope SE facing
Softwood	Softwood	Softwood	Slope crest
Softwood	Softwood	Softwood	Steep slope
Softwood	Softwood	Softwood	Wet flats
Softwood	Softwood	Softwood	Wet flats on coarse seds
Mixed	Mixed	Mixed	Dry flats, mod calc sed/metased

Literature Citation

Bailey, Robert. 1997. Ecoregions of North America. U.S. Dept. of Agriculture, Forest Service, Washington, DC. Map.

Groves, Craig; L. Valutis; D. Vosick; B. Neely; K. Wheaton; J. Touval and B. Runnels. 2000. Designing a Geography of Hope: A Practitioner's Handbook for Ecoregional Conservation Planning, Volume II. The Nature Conservancy. Pgs. A6-1 to A6-4.

Homer, Joseph W.; M.E. Cannon and T. Burke. 2004. Order II Soil Survey of the Umbagog Wildlife Refuge Area, Coos County, New Hampshire, Oxford County, Maine. USDA Natural Resources Conservation Service, Lancaster, NH. 139 pp and map.

Kuchler, A. W. 1964. Manual to Accompany the Map, Potential Natural Vegetation of the Conterminous United States. American Geographical Society Special Publication No. 36. American Geographical Society, New York, NY.

U.S. Fish and Wildlife Service, 2001. Policy on Maintaining the Biological Integrity, Diversity, and Environmental Health of the National Wildlife Refuge System. U.S. Fish and Wildlife Service Manual, 601 FW3. 66 Fed. Reg. 3817.